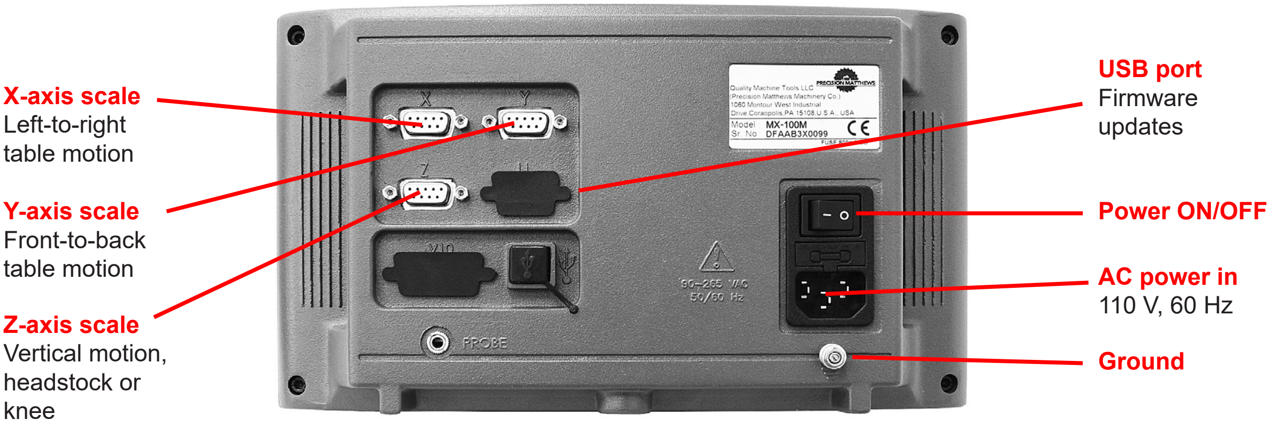
MagXact MX-100M MILL DRO



The MagXact mill DRO is a 3-axis unit with magnetic scales, 5 micron resolution. The procedure for installing the scales is described in other Precision Matthews publications, and is not repeated here.

FIRST USE

1. Connect the three scales on the mill as shown above.
2. Connect 110Vac power to the DRO through a ***surge protector.***
3. If the 110Vac outlet is not reliably grounded, connect a ***ground wire*** between the mill and DRO.

The system should now be immediately functional, with the three numerical displays responding to machine movements.

Power-up display

The model number on the display should read **EL403**, followed by a version number (**vEr**) depending on the date of manufacture.

FAQ Why does the display report machine motion incorrectly?

The standard MagXact package for the mill has 5 micron (0.005 mm = 0.0002") resolution scales. If you have installed a special-order package with 1 micron (0.001 mm) scales, the display will report 5X actual movement.

This is a parameter setting, see the following page.

FAQ Do the numerical displays work like this?

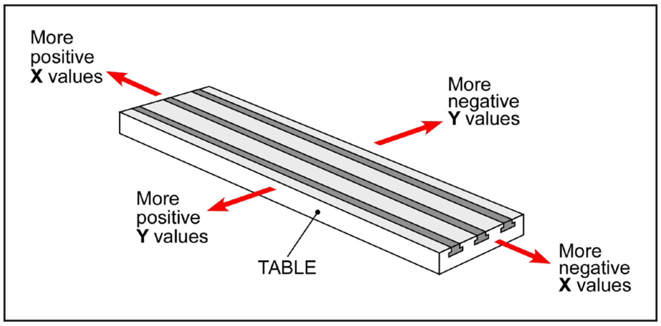


Figure 1 **A suggested sign convention**

In this diagram the X value becomes more positive as the table moves to the left; similarly, the Y value becomes more positive as the table moves forward, toward you. This is a matter of choice, not an industry-wide convention (there isn't one). The only time to be concerned about this is when you are running a pre-programmed macro routine such as PCD (hole circle) — this may give unexpected results if you are not set up as in the diagram. Otherwise, use whatever setup you wish.

Display direction vs. table motion is a parameter setting, see the following page.

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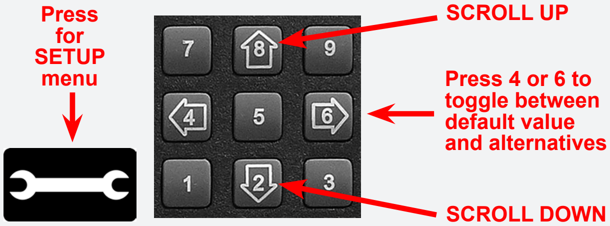
SETUP MENU


Press for SETUP menu
7
8
9
4
5
6
1
2
3
SCROLL UP
Press 4 or 6 to toggle between default value and alternatives
SCROLL DOWN

*Items in **BLUE** are not described here. For items in **RED** see the last page of this manual.*

Press the **wrench** key at bottom left of the DRO. This will display **SELECT** in the uppermost (X axis) window.

- Three of the main menu items relate to a specific axis, X, Y or Z: these items are ***scale resolution***, ***display resolution***, and ***scale direction***. Select the machine axis you wish to work on by pressing one of the three keys **X**, **Y** or **Z**.

- Press the **2** key (down arrow) to scroll down one step in setup menu to display **LINEAR** (the default). If **ANGULAR** is displayed instead, press the **4** or **6** key to switch to **LINEAR**. Press **2**.

- **SC** (Scale Resolution in microns: **5** is the default setting for mills). ***Skip this parameter*** if the selected axis is reporting travel distance correctly. If not, press the **4** key (left arrow) to display **1.0**, assuming a 1 micron scale, (or another value, corresponding to the installed scale's resolution). Press **2**.

- **DP** (Display Resolution, in microns: **5** is the default setting for mills, same as scale resolution).***Skip this parameter*** if you like the display to report motion in 0.0002 inch increments. If this is too sensitive, consider reducing the display resolution to 50. The display will then be to the nearest 0.002 inches, only 3 digits right of the decimal instead of four. Press **2**.

- **RAD** (radius) or **DIA** (diameter). This applies only to lathe installations. Press the **4** or **6** key to select **RAD**. If **DIA** is selected the numerical display will report one-half of the real distance traveled (a "phi" sign **Ø** will be displayed to the right of the numbers). Press **2**.

- **LEFT/RIGHT**, Scale Direction (do the numbers go positive or negative for a given motion of the table or headstock?) ***Skip this parameter*** if you like how the selected axis displays numbers, see the preceding page. If you prefer the "other" direction, press the **6** key (right arrow) to display **Right**. The default setting, **Left**, is arbitrary because the display cannot detect how the scales are physically installed (which way up, left side, right side, etc.).

- ***CAL***, error compensation. Press **2**.
- ***ENF OFF***, measuring system error. Press **2**.
- ***AUX FN***, auxiliary functions. Press **2**.
- ***LOCK***, keypad lock (leave OFF).

- ***ZERO AP***, zero approach warning. See the last page. Press **2**.

- **BEEP**. If you like an audible confirmation of every key action (or error), leave **ON**. If not, press the **4** or **6** key to switch **OFF**. See also the last page. Press **2**.

- **SLEEP T**, display time-out period, zero to 120 minutes. Press **ent** to display the selected period (default is **000**, display doesn't time-out). Press **ent** again (displays **0**), key in the desired number of minutes, then press **ent** again to confirm. Press **2**.

  (When the display times-out, a red LED below the wrench key flashes continuously. To wake up the display, press any of the axis keys, X, Y or Z.)

- ***FILTER***, not applicable to mills. Press **2**.

- **SAV CHG**, save changes. Press the **ent** key to confirm. Press **2**.

- ***RST OEM***. Press **2**.

- **OEM MODE**. See the last page. Press **2**.

- **END**. Press the **ent** key to exit the setup mode. *(Another way to exit the setup mode at any point in the menu is to press the **C** key two times.)*

COORDINATES

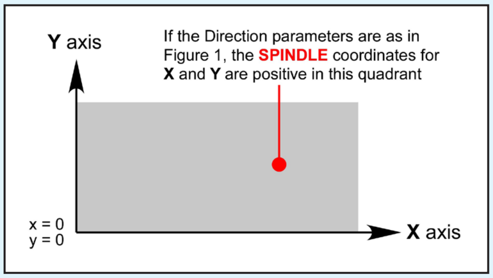
Coordinates are used to specify a point on a map by how far east it is from a reference point, and how far north. In milling machine terms, think of the map lying flat on the table, with south toward you. Westerly or easterly travel on the map corresponds to longitudinal motion of the table, the ***X axis***. Similarly, the north/south ***Y axis*** corresponds to the other direction of table movement, toward you, or back.

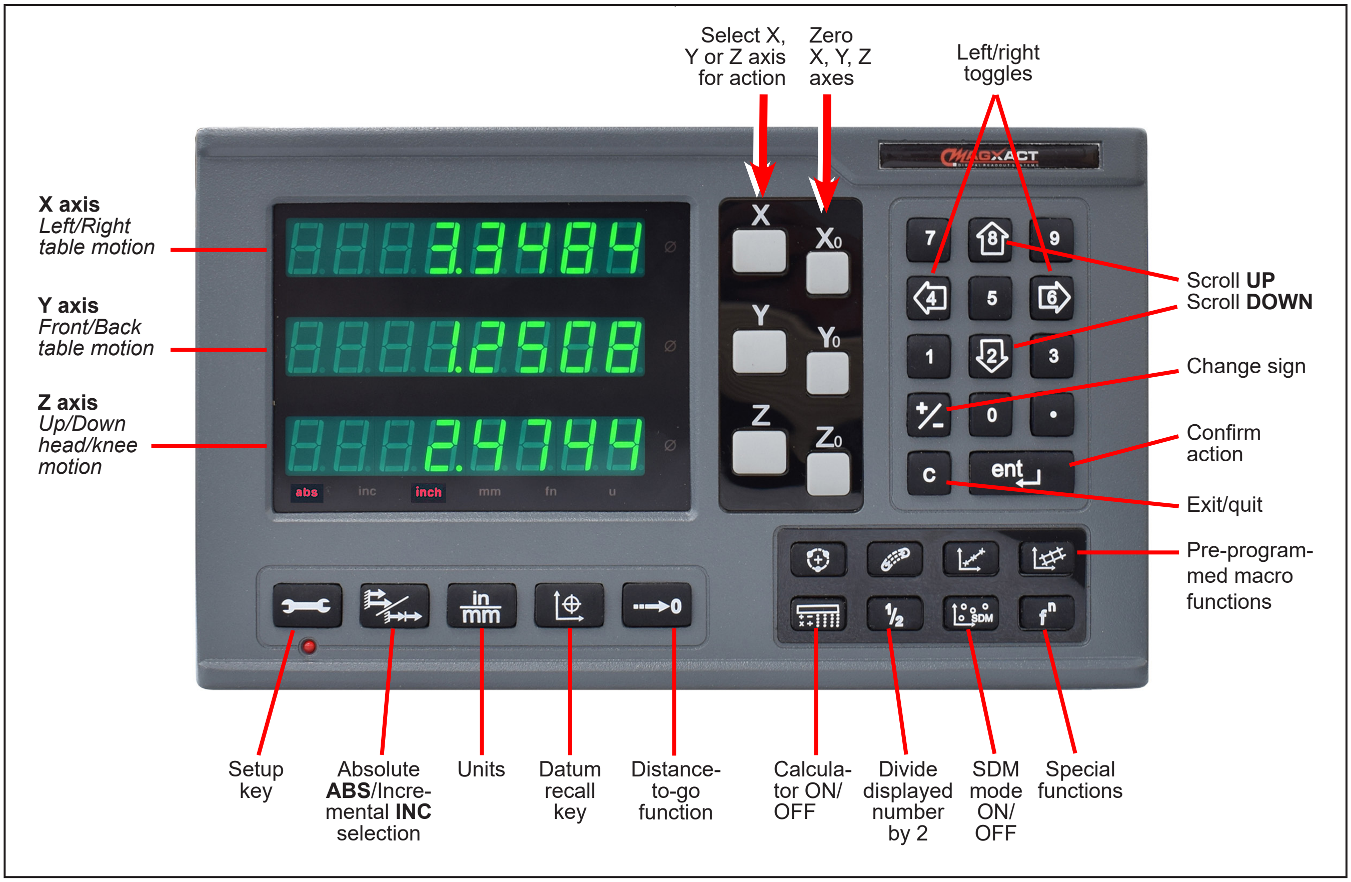
It follows that a pair of X and Y values, the XY coordinates, completely define a point in the “XY plane” — in other words, the mill table. If the project is simply to drill holes in a flat workpiece, all you need are X and Y coordinate pairs, as many

The coordinate sign contradiction

Coordinate sign is a source of much confusion. Figure 1 shows the displayed value becoming more positive when the table moves to the left. Why is this, when we usually think of a leftward motion as "becoming less"? Should it be the other way around? No!

Forget table motion as viewed by you in the ordinary way, facing the machine. Imagine instead that you are looking down from the cutting tool as it travels across the workpiece. From this viewpoint a left-moving table has the tool in effect moving to the right, which is the conventional positive direction in coordinate geometry.


Y axis
If the Direction parameters are as in Figure 1, the SPINDLE coordinates for X and Y are positive in this quadrant
x = 0
y = 0
X axis



pairs as there are holes. But for less straightforward projects, we need the “third dimension” to specify (say) depth of the holes, or the vertical distance between two horizontal surfaces. This is the ***Z axis*** dimension, which has to do with the height of the headstock relative to the workpiece.

A second Z factor is quill position — think "drill-press action". This is not reported on a three-axis DRO because it is totally independent of headstock height (some mills have a separate quill DRO in the headstock.

OTHER SIGN vs. DIRECTION FACTORS ...

When talking "direction", you need to be specific about which is relative to what. For example, your sense of positive or negative can depend on your choice of workpiece datum — left side or right side, front or back. There are two other variables to consider:

1. How the scales were installed on the mill. The Y axis scale could be on either the left or right of the saddle. Ditto the Z axis scale, left or right of the column or knee. The X axis scale is mostly — but not in every case — at the back of the table.
2. No matter how the scales were installed, how the DRO handles output from the scales depends on your setting of the **Left/Right** parameter, see **SETUP MENU** on page 1.

What it comes down to is this: for routine shop work go with whichever direction setup you prefer. It really doesn’t matter, unless you are using sub-datums, or one of the DRO’s pre-programmed macros, such as Bolt Hole Circle (PCD, pitch circle diameter). For these actions, use the sign convention shown in Figure 1.

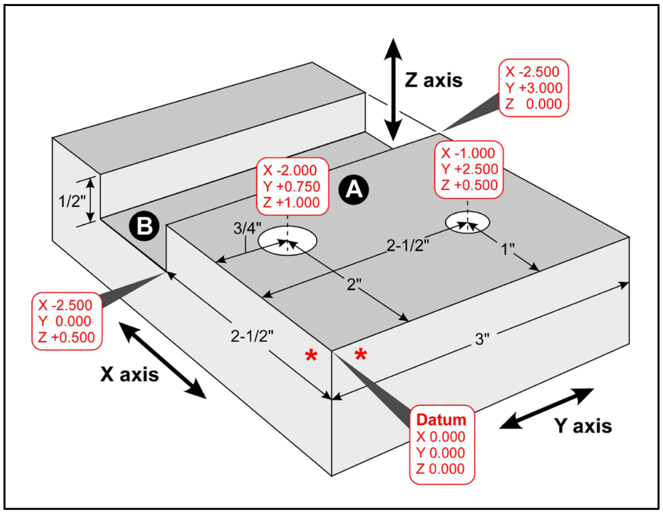


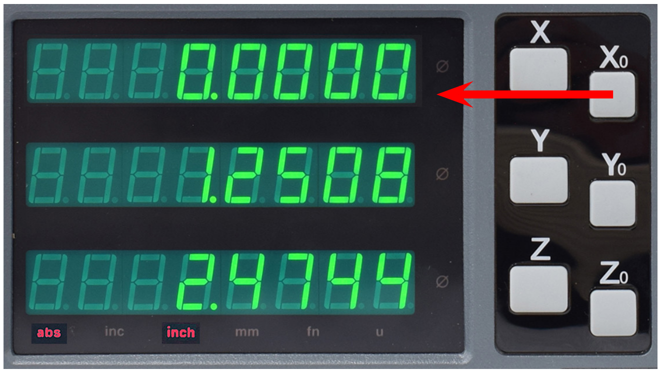
Figure 2 **Real-life measurements and coordinate equivalents**
By using an edge finder on the asterisked surfaces, the lower right corner of the workpiece has been defined in this example as the datum, the point where X and Y values are both zero. The Z axis is assumed to be zeroed at the point where the cutting tool just touches the workpiece. The Z coordinates shown here indicate that the Z display goes positive as the cutting depth increases, from surface A to surface B. This a user preference.

The two holes have negative X and positive Y coordinates. Referring to Figure 1, this is because positioning the spindle over these locations calls for the table to be moved to the right (X), and brought forward (Y). If the DRO is set up with a different sign convention, the sign of one or both of the X and Y values will also change. ***This also applies if the datum is chosen to be at a different location, such as lower left.***

BASIC FUNCTIONS

ZEROING THE DISPLAY

Press the **Xo** button to zero the table's current longitudinal position. The Y and Z axes are zeroed in a similar way, **Yo** and **Zo**.

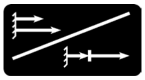


INCHES vs. METRIC UNITS

Press the **in/mm** key at any time to switch the display system from inches to millimeters, and vice versa.

CHOICE OF abs OR inc MODES

abs stands for Absolute Mode, **inc** for Incremental Mode. Switch from one to the other by pressing the "arrows" key at bottom left.



The selected mode is indicated by red LEDs **abs** or **inc**. Superficially, the two modes seem to be similar — both display XYZ coordinates in the same way, and both can be zeroed by pressing the **Xo**, **Yo** and **Zo** keys. The **abs** (absolute) coordinate frame is generally thought of as being fixed relative to the workpiece datum. The **inc** (incremental) coordinate frame is set arbitrarily at any time in the machining process. **inc** has no fixed relationship to **abs**.

Some users are content with whatever mode the DRO happens to be in when switched on. Others set up **abs** coordinates at the beginning of a work session, and thereafter work in the **inc** mode — knowing that the starting coordinates are ***available at any time*** simply by switching back to **abs**.

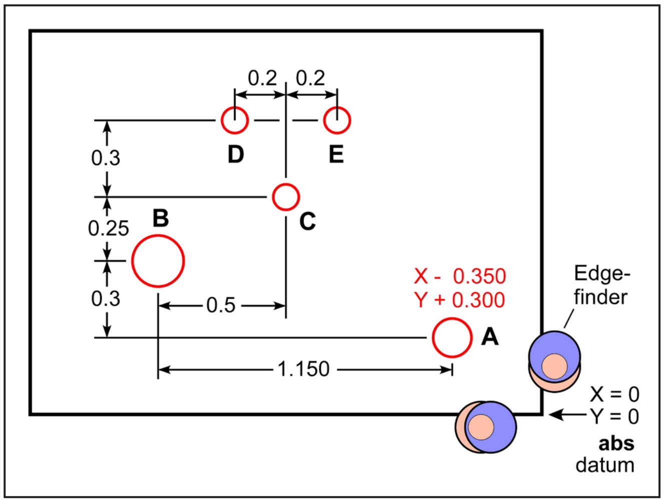


Figure 3 **Using abs and inc modes**

The following example illustrates one possible way of using a combination of **abs** and **inc** modes:

1. Select a workpiece datum. In Figure 3 the bottom right hand corner has been "found" in the **abs** mode, and the XY coordinates have been set to zero.
2. In **abs** mode drill Hole A at X - 0.350, Y + 0.300.
3. For Hole B move the table 1.15 right to display X - 1.5 (-0.35 -1.15), and forward to Y + 0.6 (0.3 + 0.3). This is easy math, so stay in **abs** mode.
4. The group of smaller holes C, D, E is located by reference to Hole B. One possibility is to stay in ABS mode and move to C, D, E using mental arithmetic as before — but it's easier to switch to **inc** mode, then zero X and Y at the B location.
5. In **inc** mode Hole C is +0.5 away from B in X, and +0.25 in Y. Drill Hole C, then zero X and Y at C before moving on to D and E.

None of the above affects the abs datum, so the starting point can be recaptured at any time.

CENTER FIND

Locating the exact center of a workpiece is one of the most used applications of the DRO. These examples show a conventional edge finder with spring-loaded tip; when the tip just touches the workpiece edge it kicks out suddenly — edge "found". It helps to use a high spindle speed for edge finding.

(1) Center of rectangular workpiece

1. With the DRO in **inc** mode, and the edge finder positioned as Figure 4(A), run the table slowly forward to the point where the edge finder tip kicks out at the leading edge of the workpiece.
2. Press the **Yo** key to zero the Y axis.
3. Raise the edge finder clear of the workpiece.
4. Taking care not to disturb the table's X position, raise the spindle, then locate the edge finder behind the workpiece.
5. Lower the edge finder, inset Figure 4(B).
6. Move the table away from you to "find" the back edge of the workpiece, then press the **1/2** key (bottom left of the calculator group) to display **SELECT**.
7. Press **Y** key.

Now, when the Y display reads **0.0000**, the spindle is exactly over the Y axis mid-point between front and back edges. ***Repeat the above steps at left and right edges of the workpiece to find the X axis mid-point.***

(2) Center of circular objects

Mid-point locating as described above is not only for rectangular objects. It can also be used to find the center of ***circular objects***. Examples: 1. Locating the center of a circular bar, maybe to center-drill it for lathe work, Figure 5, and; 2. Locating the center of a hole to be enlarged, Figure 6.

Locate the edge finder as near to the estimated centerline as possible before touching the edge. It does not have to be exactly on center, but the "other axis" ***must not move*** when you traverse from one side of the feature to the other — clamp it if necessary.

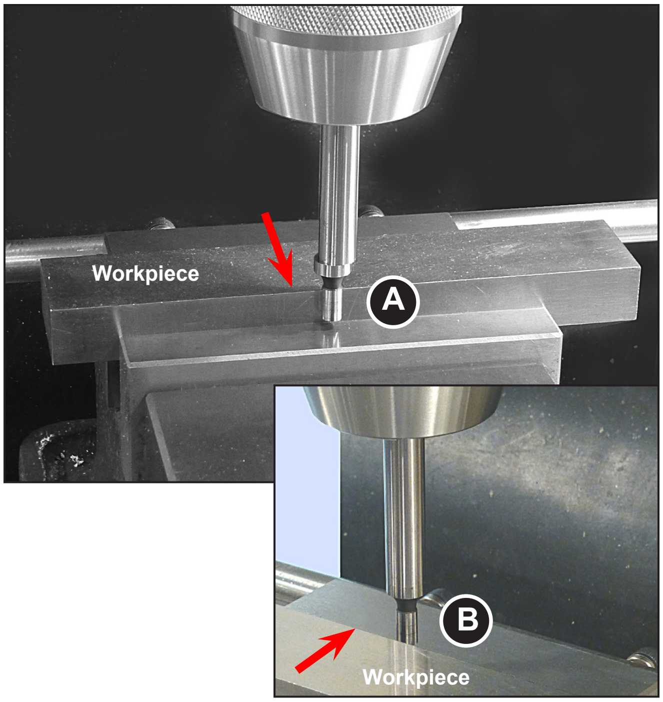
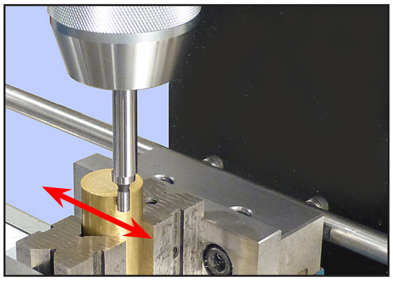


Figure 4 **Finding the Y axis center on a rectangular workpiece**



! *The item must be truly circular for a reliable result*

Figure 5 **Finding the X axis center on a circular bar**
*Be sure the Y axis location of the table is **exactly the same** when finding the left and right edges of the bar.*

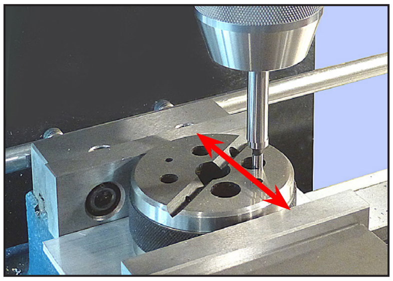


Figure 6 **Finding the Y axis center of a circular hole**
*Be sure the X axis location of the table is **exactly the same** when finding the front and back edges of the hole.*

CENTER-FINDING MACRO ROUTINE

The DRO has a pre-programmed macro that in some cases may be more convenient than finding the X and Y axis centers separately as in Figures 5 and 6.

To see how the center-finding macro functions, imagine a rectangle just touching the circumference of a circle, radius R, Figure 7. The rectangle is aligned with the mill's X and Y axes. The distance between opposing corners equals **2 x R**. Given the coordinates of corners 1, 2 and 3 the macro calculates the coordinates of the center.

The corner coordinates can be determined using a mechanical edge finder, as in Figure 4, but an electronic touch sensor is preferable.

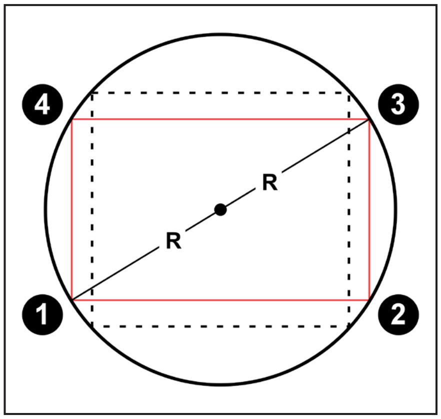


Figure 7 **Center-finding schematic**
The closer the rectangle is to square the better the result. Set the mill spindle over the eyeball-estimated center of the circular hole or disk, then move the table back by about 2/3 of the circle's radius, R.

Center-finding procedure

In this example a bar is to be center-drilled for turning.

Position the workpiece so that the spindle is directly over the approximate center of the circular rod, Figures 8, then run the table back about 2/3 of the circle's radius to bring the spindle over the line 1-2. The exact distance is not critical.

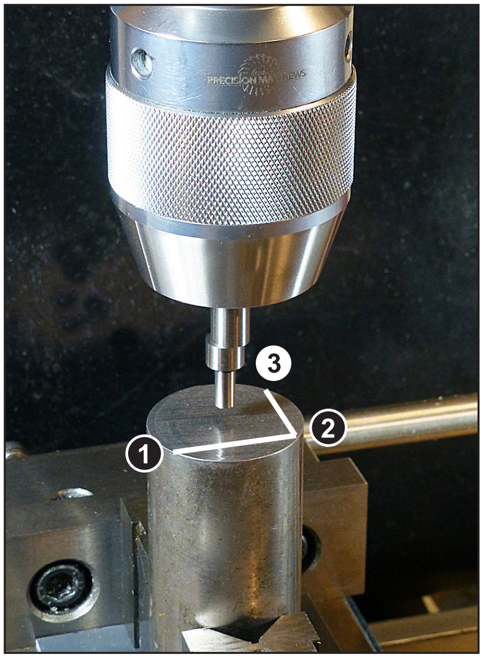


Figure 8 **Align the spindle over the approximate center**

1. In either **inc** or **abs** mode, press the function key, displaying **CENTER**.

f^n **Function key**

2. Press the **ent** key. Press the **4** or **6** keys if necessary to display **CIRCLE**.
3. Press the **ent** key again, displaying **Point 1** in the Z axis window.
4. Find the perimeter of the bar at location 1. Press the **6** key to save the location's coordinates. ***Do not move the table forward or back*** again until Step 6.
5. With Y coordinate ***unchanged***, traverse the table, then find the perimeter of the bar at location 2. Press the **6** key to save the location's coordinates. ***Do not move the table left or right*** again.
6. With the X coordinate ***unchanged***, move the table forward, then find the perimeter of the bar at location 3. Press the **6** key to save the location's coordinates.

Pressing the **6** key at location 3 completes the routine, displaying **CENTER** in the Z axis window, together with the center coordinates in the X and Y windows. Zero the values by table movement to bring the spindle exactly over the center of the bar.

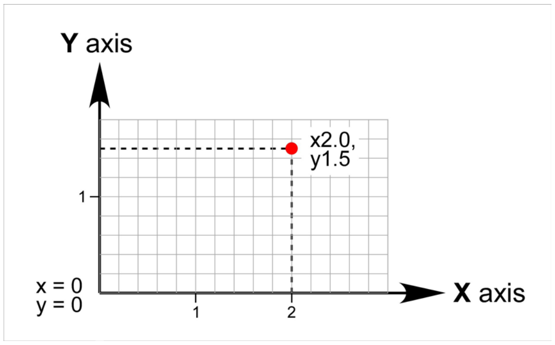
The extra "decimal point" left of the numerical display in the X and Y windows signifies that the function mode is active.

Exit the function by pressing the **C** key.

DIRECT ENTRY OF COORDINATES

It is sometimes desirable to establish specific new coordinate values for whatever position the table happens to be in at the moment (the same could apply to the headstock or knee). Provided you do this in the **inc** mode, the **abs** zero will not be affected. In this example, we will "tell" the DRO that the table's current position is X = 2.0, Y = 1.5. ***Table movement vs. display direction is important here***, see Figure 1.

1. Select **inc** mode.
2. Press the **X** key to select the X axis. The X window displays **0**.
3. Using the keypad enter **2.0**, then press the **ent** key to confirm.
4. Press the **Y** key to select the Y axis. The Y window displays **0**.
5. Using the keypad enter **1.5**, then press the **ent** key to confirm.



You have now "placed" the table at X 2.0, Y 1.5, no matter what its position might be in the **abs** mode. Movement of the table to the **right**, the negative-going direction, will lower the X value (heading for zero). Similarly, moving the table **back** toward the column will reduce the Y value.

SUB-DATUM SYSTEM

The **abs** (absolute) coordinate frame is generally thought of as being fixed relative to the workpiece datum. The **inc** (incremental) coordinate frame is set arbitrarily at any time in the machining process. **inc** has no fixed relationship to **abs**.

The DRO provides the means of setting up a number of secondary **abs** coordinate frames known as ***sub-datums*** (up to 1000 of them in fact). They behave in exactly the same way as the “native” **abs**, and ***are referenced to the abs datum***.

! This means that if **abs** is re-zeroed at a new location, all sub-datums are moved in lockstep.

Sub-datums, **SDMs**, are helpful in machining operations calling for more than one point of reference. If the sub-datum function did not exist, “virtual datums” could be established by zeroing in the INC mode at any time in the machining process. The shortcoming of that approach, compared to true sub-datums, is that virtual datums are not related to each other in a specific way, nor are they related to the **abs** datum, other than by the offset numbers (which — ***maybe*** — you will have remembered to make a hand-written record of).

Sub-datums cannot be used for the macro routines Hole Circle (PCD), Angle Hole and Grid. These can only be run in the abs mode.

Sub-datum values can be established in two different ways, referred to as **"Learn" Method** and **"Direct Entry" Method**.

In the "Learn" Method the table is moved to bring the spindle to each of the SDMs in turn. In the "Direct Entry" Method the SDM coordinates, relative to the **abs** datum, are entered directly from the numeric keypad.

The following illustrations refer to Figure 9. Here, the **abs** datum is at bottom left. This is arbitrary: in practice the **abs** datum could be established at any corner, or at any other location chosen to simplify the machining process. ***But bear in mind*** the effect this may have on coordinate signs.

The first of the "Learn" Method illustrations sets up three SDMs in series. This is followed by an example of setting up a single SDM, in this case overwriting an existing SDM.

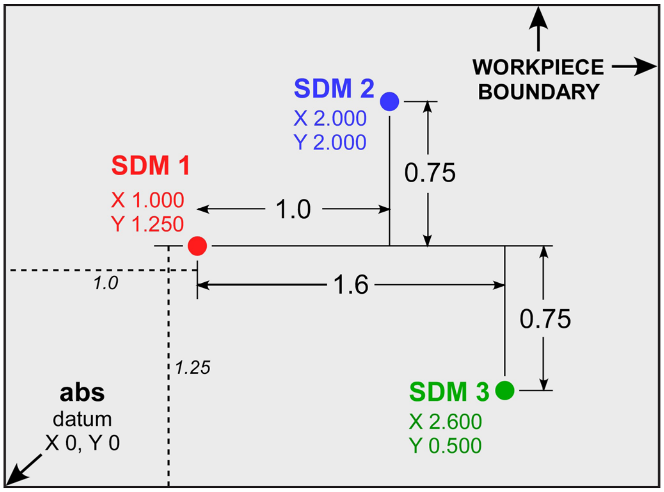
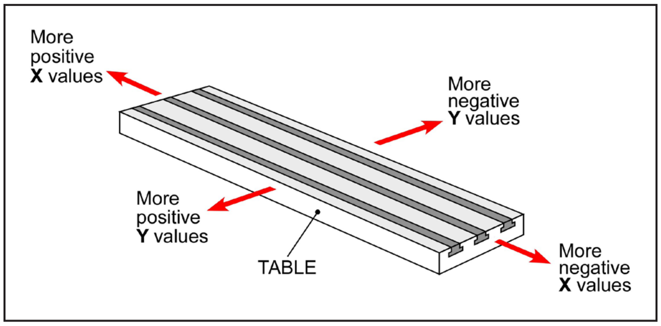


Figure 9 **SDM example**

Table movement vs. display direction (positive or negative going), is important. The convention used in these examples is as in Figure 1, repeated here.



Regardless of how you set up your SDMs, it is a good idea to mark their approximate locations on the workpiece. A few seconds with a magic marker can help avoid gross mistakes due to sign errors. ***ALWAYS*** dry run to the SDMs before beginning to machine.

The Z axis display is ignored in the following illustrations.

SETTING UP SDMs: "LEARN" Method

SDM key

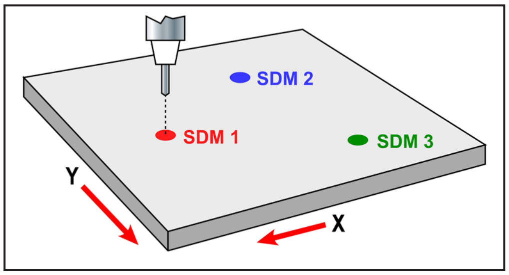
1. Select **abs** mode.
2. Establish the **abs** datum by edge finding or other means (in Figure 9 the lower left corner is the chosen point for **abs** zero). Press **Xo** and **Yo** to set X=0, Y=0.
3. Staying in the **abs** mode, press the **SDM** key to display **PROGRAM** and function **fn** (red LED).

abs	inch	fn

4. Press the **6** key twice to display **LEARN**.
5. Press the **ent** key to confirm LEARN mode. **STEP No** is displayed in the X window. (Ignore the numeral **1** in the Y window: it is not meaningful at this point.)

SDM 1 setup

1. To initiate the setup, press the **Y** key (this is simply a programming step: it is not specific here to the Y axis). The numeral **1** in the Y window changes to **0** when the Y key is pressed.
2. On the keypad enter the SDM number you are about to learn, in this case **1**, then press the **ent** key to confirm, displaying **X 0.0000**, **Y 0.0000**.
3. Move the table left 1.0", forward 1.25", displaying **X 1.000**, **Y 1.250**.
4. Press the **6** key once to display the SDM number you are working on (in this case **STP1**), then press the **6** key again to ***save*** the current table position as **SDM 1**.



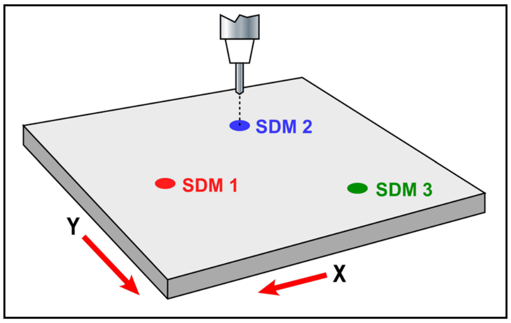
Left movement increases X value, Forward movement increases Y

SDM 2 setup

The following assumes you are starting at SDM 1.

1. Move the table left 1.0", forward 0.75", displaying **X 2.000**, **Y 2.000**.
2. Press the **6** key once to display the SDM number you are working on, now **STP2**, then press the **6** key again to ***save*** the current table position as **SDM 2**.

Left movement increases X value, Forward movement increases Y

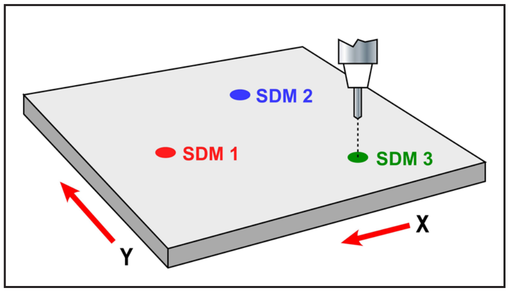


SDM 3 setup

The following assumes you are starting at SDM 2.

1. Move the table left 0.6", back 1.5", displaying **X 2.600**, **Y 0.0500**.
2. Press the **6** key once to display the SDM number you are working on, now **STP3**, then press the **6** key again to ***save*** the current table position as **SDM 3**.

Left movement increases X value, Backward movement decreases Y



Exit the SDM mode

at any time by pressing the **C** key. This returns the DRO to normal operation, turning off the function **fn** light.

Setting up a single SDM by the "LEARN" Method

This could be any SDM number, in any location. It does not follow in sequence from any previously set SDM.

In Figure 10 , below and following page, we will overwrite the previously set up coordinates of SDM3.

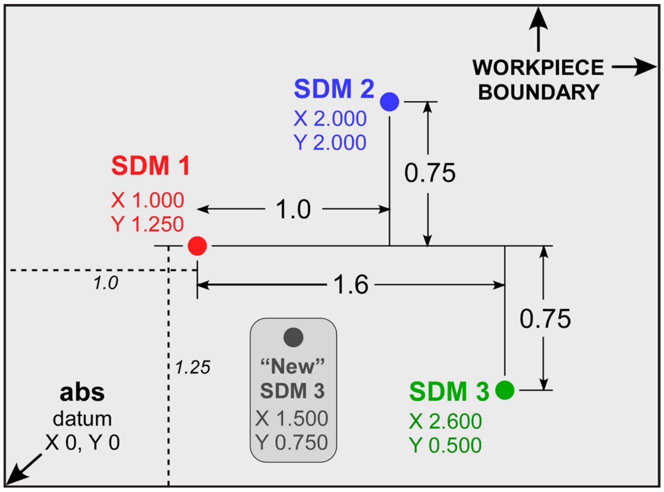


Figure 10 **Setting up a new value for SDM3**

1. Select **abs** mode.
2. Establish the **abs** datum as Figure 9 by edge finding or other means. Press **Xo** and **Yo** to set X=0, Y=0.
3. Staying in the **abs** mode, press the **SDM** key to display **PROGRAM** and **fn** (red LED).

abs **inch** **fn**

4. Press the **6** key twice to display **LEARN**.
5. Press the **ent** key to confirm LEARN mode. STEP No is displayed in the X window. (Ignore the numeral **1** in the Y window: it is not meaningful at this point.)
6. Press the Y key. The numeral **1** in the Y window changes to **0** when the Y key is pressed.
7. On the keypad enter the SDM number you are about to learn, in this case **3**, then press the **ent** key to confirm, displaying **X 0.0000**, **Y 0.0000**.
8. Move the table to display the new location for SDM3. This could be anywhere within the workpiece. The arbitrary values shown in Figure 9 are **X 1.500**, **Y 0.750**.
9. Press the **6** key once to display the SDM number you are working on (in this case **STP3**), then press the **6** key again to ***save*** the current table position as the new **SDM 3**.
10. Press **C** to exit the SDM mode, turning off the **fn** light and returning the DRO to normal operation.

SETTING UP SDMs: "DIRECT ENTRY" Method

When using the Direct Entry method to program SDMs be especially careful with the setup for table movement vs. display direction.

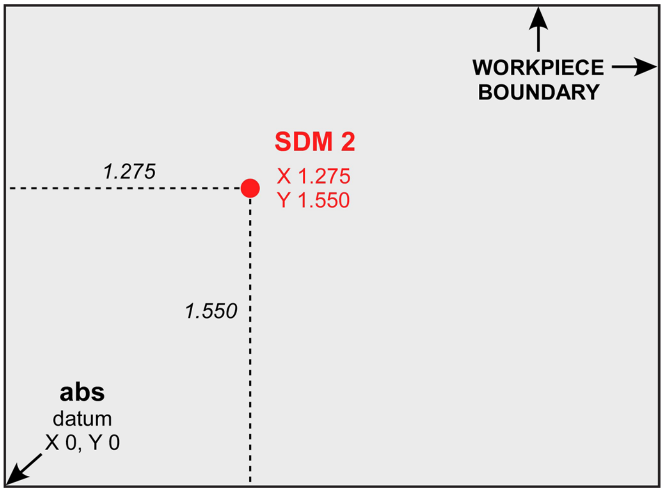


Figure 11 **Setting up coordinates for SDM1 by Direct Entry**

Here, we are setting up **SDM2**, see Figure 11. Previously entered coordinates for SDM2, if any, will be over-written by this procedure.

1. Select **abs** mode.
2. Establish the **abs** datum as Figure 9 by edge finding or other means. Press **Xo** and **Yo** to set X=0, Y=0.
3. Staying in the **abs** mode, press the **SDM** key to display **PROGRAM** and **fn** (red LED).

abs **inch** **fn**

4. Press the **ent** key to display **STEPNo** in the X window, and **1** in the Y window (the **1** is not a meaningful value).
5. Press the **Y** key (this is simply a programming step: it is not specific here to the Y axis). The numeral **1** in the Y window changes to **0** when the Y key is pressed.
6. On the keypad enter the SDM number you are about to program, in this case **2**, then press the **ent** key to confirm.
7. Press the **X** key to zero the X memory for SDM2 (the displayed X value changes to **0**). On the keypad enter the X value **1.275**, followed by **ent** to confirm, displaying **X 001.2750**.

OOPS! *Mistakes in data entry can be corrected, digit by digit, by pressing the C key as many times as needed (but pressing C too many times will exit the SDM mode).*

8. Press the **Y** key to zero the Y memory for SDM2 (the displayed Y value changes to **0**). On the keypad enter the Y value **1.55**, followed by **ent** to confirm, displaying **Y 001.550**.
9. SDM2 has now been programmed. Press **C** to exit the SDM mode, turning off the **fn** light and returning the DRO to normal operation.

RECALLING & USING SDMs

In the following illustration we will recall **SDM2**, set up as above by either the LEARN or DIRECT ENTRY method.

1. Select **abs** mode.
2. Press the **SDM** key to display **PROGRAM** and **fn** (red LED).
3. Press the **6** key once to display **RUN**.
4. Press the **ent** key to confirm RUN mode, displaying **STEP No** in the X window, and **1** in the Y window (the **1** is not a meaningful value).
5. Press the Y key. The numeral **1** in the Y window changes to **0** when the Y key is pressed.
6. On the keypad enter the SDM number you wish to recall, in this case **2**, then press the **ent** key to confirm.

inc **inch** **fn**

The display switches to **inc** mode, displaying an ***extra "decimal point"*** to the left of the values in the X and Y windows. These values do not signify table ***position***. They are instead ***distances-to-go*** from where the table is now to the chosen SDM point.

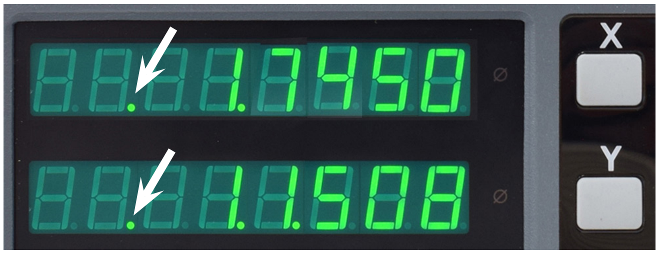


Figure 12 **Distance-to-go markers**

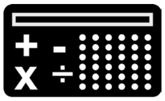
7. Move the table to zero the X and Y values. ***You are now at SDM2***. Table movement thereafter in the **inc** mode is relative to the SDM2 zero point. Press the **C** key to exit the SDM RUN mode and return to the **abs** mode.

The extra points on the X and Y displays remain as long as you are "running" in the SDM mode.

The zero approach warning can be used in the SDM mode. See the last page of this manual.

MATH CALCULATIONS

The DRO calculator is like a basic handheld, except that it has no memory function. It can be used in the ordinary way for all basic math functions.



Calculator key

- Press the calculator key to activate the calculator. Press it again to return to normal DRO functions.

- If you make a mistake when entering a value, press the **C** key to clear the display, and start over.

- The math functions available are not shown on the keypad. They are displayed one after the other in the Y window when the **Y** key is pressed repeatedly. The functions are:

ADD	Add
SUB	Subtract
MULTI	Multiply
DIV	Divide
SIN	sine
COS	cosine
TAN	tangent
ASIN	arcsine
ACOS	arc cosine
ATAN	arc tangent

How to use the calculator — general procedure

1. Using the keypad enter the first value in the X window.
2. Press the **Y** key as many times as needed to display the desired math function, such as ADD, MULTI, COS.
3. To change sign of an entry, press the **+/-** key before or after entering the value.
4. Press the **ent** key to display the result.

Examples

Calculate 12 + 34 + 56

- Using the keypad enter the first value **1 2**
- Press the **Y** key once to display **ADD**
- Using the keypad enter the second value **3 4**
- Press the **ent** key to display the result **46**

OOPS! You forgot to add **56**, the third term? Simply press the **Y** key again to display **ADD**, then enter **5 6**, followed by the **ent** key to display the result **102**.

Calculate 50 - 15 - 10

- Using the keypad enter the first value **5 0**
- Press the **Y** key twice to display **SUB**
- Using the keypad enter the second value **1 5**
- Press the **Y** key twice to display **SUB**
- Using the keypad enter the third value **1 0**
- Press the **ent** key to display the result **25**

Calculate 7 x cos 30

- Using the keypad enter the angle **3 0**
- Press the **Y** key six times to display **COS**
- Press the **ent** key to display the result **0.866025**
- Press the **Y** key thee times to display **MULTI**
- Using the keypad enter the multiplier **7**
- Press the **ent** key to display the result **6.062175**

HOLE DRILLING PROGRAMS

The DRO has five pre-programmed macro routines that automate frequently used processes in the machine shop:

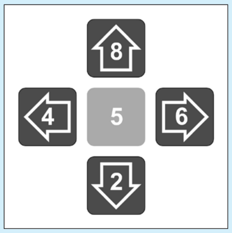
Bolt circle drilling — PCD macro (full circle)
Bolt circle drilling — PCD macro (arc)
Arc contouring — Arc-nibbling (step-drilling) macro
Holes-in-line drilling — Angle Hole macro
Grid drilling — Grid macro

GENERAL PROCEDURES FOR MACROS

- Work in the **abs** mode only.
- Data entry error: Press the **C** key as many times as needed to clear the display digit-by-digit (too many presses may terminate the macro).
- Change sign by pressing the **+/-** key **after** the numerical value.
- The **ent** key is usually pressed to confirm an entry.
- When all requested data has been entered, pressing the **ent** key switches the DRO into run mode, changing **abs** to **inc**, displaying ***distances-to-go***, see Figure 11.
- The first input requested is usually **ENTCNT 0**. This is code for "X axis starting coordinate".
- The second input requested is usually **ENTCNT 1**. This is code for "Y axis starting coordinate".
- **Exit** any macro function by pressing the **C** key.

Navigation keys

- Press the **6** key to advance to the next hole
- Press the **4** key to return to the previous hole
- Press the **8** key to see the current hole number, press it again to return to the program
- Press the **2** key to request a specific hole number — enter the number using the keypad. (This request is not available in the Grid macro.)



! Table movement vs. display direction (positive or negative going), is important for macro routines. The convention used in the following examples is as Figure 1.

! **The zero approach warning can be used in all macro routines. See the last page of this manual.**

BOLT CIRCLE DRILLING — FULL CIRCLE

This is sometimes referred to as PCD drilling (Pitch Circle Diameter). There are two bolt circle macros, **Full circle** and **Arc**.

To run either of these programs select the **abs** mode, making sure **abs** zero (Xo, Yo) is at the desired location relative to the workpiece. We start here with the full circle program. The numerical values in ***bold italics*** refer to the diagram, Figure 12.

PCD key

1. Press the PCD key, then press the **6** key to toggle the display between **CIRCLE** and **ARC**. Press the **ent** key to confirm **CIRCLE**.
2. Using the keypad enter the X coordinate of the circle's center (**ENTCNT 0**), ***1.750***, then press the **ent** key to confirm.
3. Enter the Y coordinate of the circle's center (**ENTCNT 1**), ***1.250***, then press the **ent** key to confirm.
4. Key in the **RADIUS**, ***0.950***, then press the **ent** key to confirm.
5. Key in the radial **ANGLE** of the first hole, ***20***, then press the **ent** key to confirm.
6. Key in the number of holes to be drilled, ***6***, then press the **ent** key to complete the data entry, and switch the display into the ***distance-to-go*** mode.
7. Move the table to zero the display, then drill hole #1.
8. Pres the **6** key to advance to the next step. Zero the display, then drill hole #2.
9. Complete the program for the remaining holes in the same way.

These options are available at any stage of the process:

- Press the **6** key to advance to the next hole
- Press the **4** key to return to the previous hole
- Press the **8** key to see the current hole number, press it again to return to the program
- Press the **2** key to request a specific hole number — enter the number using the keypad

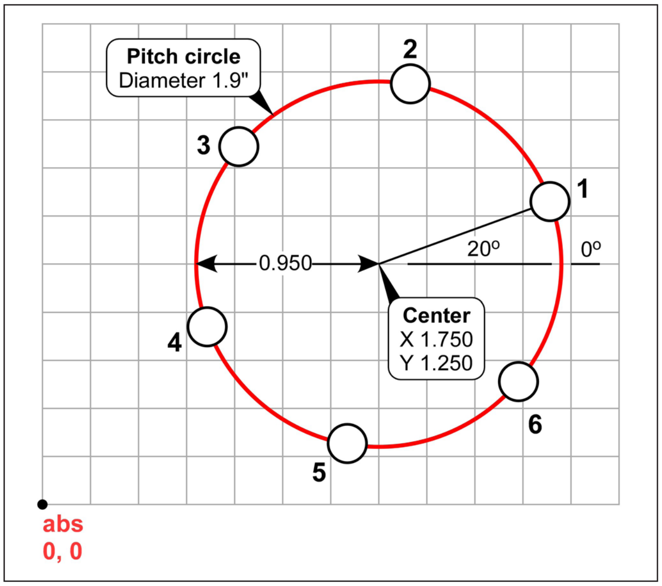


Figure 13 **Example of Full Circle bolt-hole drilling**

BOLT CIRCLE DRILLING — CIRCULAR ARC

This is sometimes referred to as PCD drilling (Pitch Circle Diameter). There are two bolt circle macros, **Full circle** and **Arc**.

To run the arc drilling program select the **abs** mode, making sure **abs** zero (Xo, Yo) is at the desired location relative to the workpiece. The numerical values in ***bold italics*** refer to the diagram, Figure 13.

PCD key

1. Press the PCD key, then press the **6** key to toggle the display between **CIRCLE** and **ARC**. Press the **ent** key to confirm **ARC**.
2. Using the keypad enter the X coordinate of the circle's center (**ENTCNT 0**), ***1.400***, then press the **ent** key to confirm.
3. Enter the Y coordinate of the circle's center (**ENTCNT 1**), ***1.100***, then press the **ent** key to confirm.
4. Key in the **RADIUS**, ***0.700***, then press the **ent** key to confirm.
5. Key in the radial **ANGLE** of the first hole, ***45***, then press the **ent** key to confirm.
6. Key in the radial angle of the last hole, ***260***, then press the **ent** key to confirm.
7. Key in the number of holes to be drilled, ***6***, then press the **ent** key to complete the data entry, and switch the display into the ***distance-to-go*** mode.
8. Move the table to zero the display, then drill hole #1.
9. Press the **6** key to advance to the next step. Zero the display, then drill hole #2.
10. Complete the program for the remaining holes in the same way.

Options available at any stage of the Arc drilling process are the same as those for the Full Circle macro, shown at left.

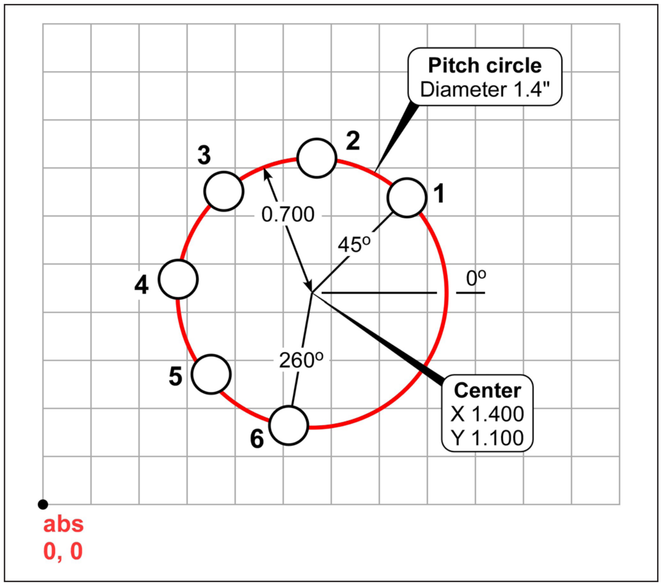
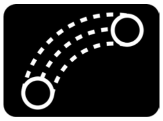


Figure 14 **Example of Circular Arc bolt-hole drilling**

ARC CONTOURING

This macro automates the process of "nibbling" an arc by step drilling in small increments. It is similar in many respects to the Circular Arc drilling macro. However, instead of setting out a circle of discrete holes, the contouring program calculates a series of overlapping hole positions in increments limited by the user — increments small enough to cut a smooth arc if desired. This is specified by the **MAX CUT** parameter, which dictates the maximum size of step between one hole center and the next. The smaller the step, the smoother the cut. "Maximum" means exactly what it says: recognizing that limitation, the DRO calculates a series of holes between start and end angles, ***evenly-spaced*** with a step size no greater than MAX CUT.

Standard twist drills are not recommended for contouring because they cannot hold position if the step size is less than about 75% of drill diameter. A better nibbling tool in most cases is a center-cutting end mill.



Arc Contour key

To run the arc contouring program select the **abs** mode, making sure **abs** zero (Xo, Yo) is at the desired location relative to the workpiece. The numerical values in ***bold italics*** refer to the diagram, Figure 15.

1. Press the Arc Contour key.
2. Using the keypad enter the X coordinate of the circle's center (**ENTCNT 0**), ***1.500***, then press the **ent** key to confirm.
3. Enter the Y coordinate of the circle's center (**ENTCNT 1**), ***1.200***, then press the **ent** key to confirm.
4. Key in the **RADIUS**, ***0.850***, then press the **ent** key to confirm.
5. Key in the radial **ANGLE** of the first hole, ***30***, then press the **ent** key to confirm.
6. Key in the radial angle of the last hole, ***120***, then press the **ent** key to confirm.
7. Key in the **TOOL DIAMETER**, ***0.1875***, then press the **ent** key to confirm.
8. Toggle the **6** key to specify that the cut is to be inside the circle **INT CUT**, outside the circle **EXT CUT**, or centered on the circle, as shown in Figure 15, ***MID CUT***. Press the **ent** key to confirm your selection.
9. The next display (difficult to read) is **MAX CUT**. In Figure 14 this is ***0.1***. This does ***not*** mean that every step is 0.1". The DRO calculates how many holes, and with what spacing — up to 0.1" — will fit between the start and end angles. The smaller the value of MAX CUT, the smoother the result.
10. Press the **ent** key to complete the data entry, and switch the display into the ***distance-to-go*** mode.
11. Move the table to zero the display, then drill hole #1.
12. Press the **6** key to advance to the next step. Zero the display, then drill hole #2.
13. Complete the program for the remaining holes in the same way.

These options are available at any stage of the arc contouring process:

- Press the **6** key to advance to the next hole
- Press the **4** key to return to the previous hole
- Press the **8** key to see the current hole number, press it again to return to the program
- Press the **2** key to request a specific hole number — enter the number using the keypad

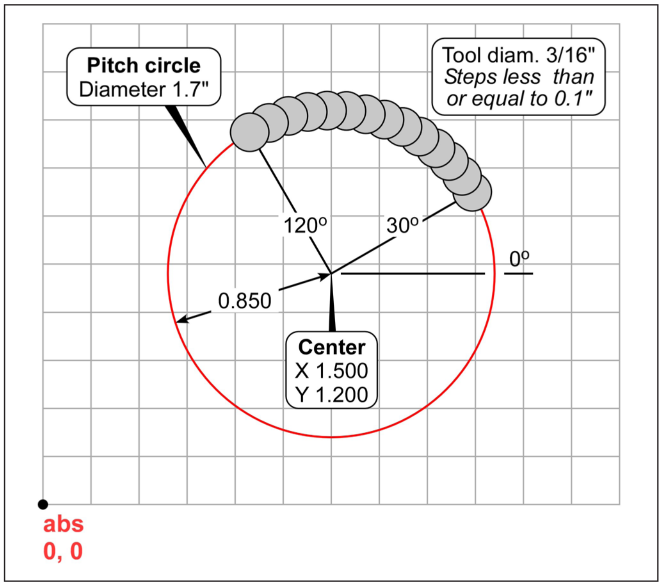


Figure 15 **Example of Arc Contouring**

BEFORE CUTTING METAL!

This is a caution for all macro routines

Check that the hole configuration calculated by the DRO is as expected. Always do a dry run by marking the rough coordinates of the holes on the workpiece with a fiber tip pen, then run the macro for comparison — maybe even doing a trial run on scrap material. If the hole layout is flipped in either the X or Y axis, or both, it may be that the ***scale direction*** parameters need attention, page 2.

DRILLING HOLES IN A LINE — "ANGLE HOLE"

This is a time-saving routine for drilling a series of holes starting at a specified location, ending at a point calculated from the ***hole count*** and the ***line angle*** relative to the X axis.

To run the Angle Hole drilling program select the **abs** mode, making sure **abs** zero (Xo, Yo) is at the desired location relative to the workpiece. Two examples are illustrated here: (1) Line angle less than 90°, Figure 15; (2) Line angle greater than 90°, on the negative side of the Y axis, Figure 16. The numerical values in ***bold italics*** refer to the diagrams.

Angle Hole key

Example (1)

1. Press the Angle Hole key.
2. Using the keypad enter the X coordinate of the first hole (**ENTCNT 0**), ***0.45***, then press the **ent** key to confirm.
3. Enter the Y coordinate of the first hole (**ENTCNT 1**), ***0.65***, then press the **ent** key to confirm.
4. Key in the **PITCH** (hole spacing), ***0.5***, then press the **ent** key to confirm.
5. Key in the line **ANGLE**, ***30***, then press the **ent** key to confirm.
6. Key in the number of **HOLES** to be drilled, ***6***, then press the **ent** key to complete the data entry, and switch the display into the ***distance-to-go*** mode.
7. Move the table to zero the display, then drill hole #1.
8. Pres the **6** key to advance to the next step. Zero the display, then drill hole #2.
9. Complete the program for the remaining holes in the same way.

These options are available at any stage of the process:

- Press the **6** key to advance to the next hole
- Press the **4** key to return to the previous hole
- Press the **8** key to see the current hole number, press it again to return to the program
- Press the **2** key to request a specific hole number — enter the number using the keypad

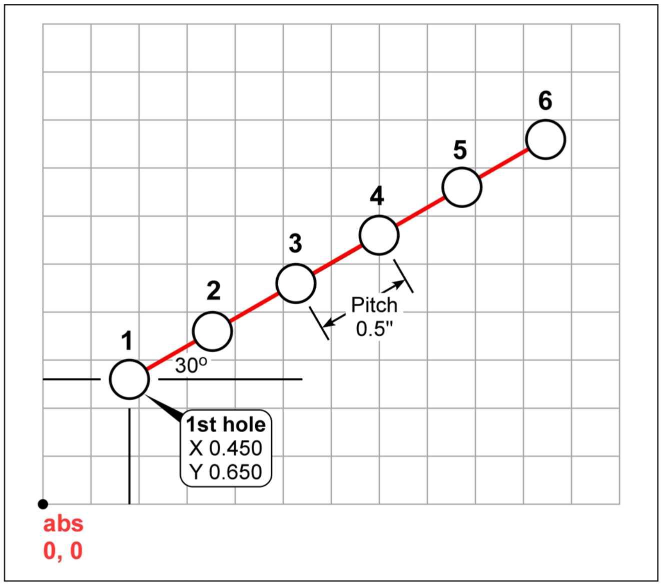


Figure 16 **Example (1) of Angle Hole drilling**

Example (2)

Except for the numerical values the procedure is the same as for Example (1). Here the values are:

ENTCNT 0 First hole X coordinate, ***0.75 -***
ENTCNT 1 First hole Y coordinate, ***0.75***
PITCH (hole spacing), ***0.7***
ANGLE, ***135***
HOLES, ***4***

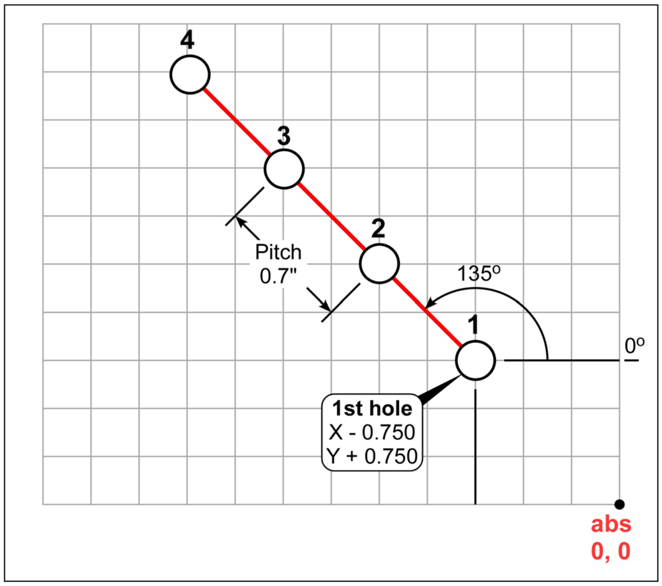


Figure 17 **Example (2) of Angle Hole drilling**

DRILLING A GRID OF HOLES

This is a time-saving routine for drilling a ***rectangular grid*** of holes, in line with the X and Y axes, or rotated by any angle.

To run the Grid program select the **abs** mode, making sure **abs** zero (Xo, Yo) is at the desired location relative to the workpiece. Two examples are illustrated here:

(1) A square (symmetrical) grid rotated by 45º, Figure 17
(2) A rectangular grid, with different X and Y pitches, rotated by 15º, Figure 18. The numerical values in ***bold italics*** refer to the diagrams.

Grid key

Example (1) Figure 18

1. Press the Grid key.
2. Using the keypad enter the X coordinate of the first hole (**ENTCNT 0**). X = ***0***, so simply press the **ent** key to confirm the default value.
3. Enter the Y coordinate of the first hole (**ENTCNT 1**), ***0.250***, then press the **ent** key to confirm.
4. Key in **PITCH X** (hole spacing in the X axis), ***0.350***, then press the **ent** key to confirm. [**Q**: How can we tell which axis is X and which is Y if this will be ambiguous when the grid is rotated 45º? **A**: At this data entry point ***zero degree rotation*** is assumed.]
5. Key in **PITCH Y** (hole spacing in the Y axis), ***0.350***, then press the **ent** key to confirm.
6. Key in **ANGLE**, ***45***, then press the **ent** key to confirm.
7. Key in **HOLES X** (number of holes in the X axis) to be drilled, ***5***, then press the **ent** key to confirm.
8. Key in **HOLES Y**, ***5***, then press the **ent** key to complete the data entry, and switch the display into the ***distance-to-go*** mode.
9. Move the table to zero the display, then drill hole #1.
10. Pres the **6** key to advance to the next step. Zero the display, then drill hole #2.
11. Complete the program for the remaining holes in the same way.

These options are available at any stage of the process:

- Press the **6** key to advance to the next hole
- Press the **4** key to return to the previous hole
- Press the **8** key to see the current pair of X and Y axis hole numbers. Press **8** again to return to the program.

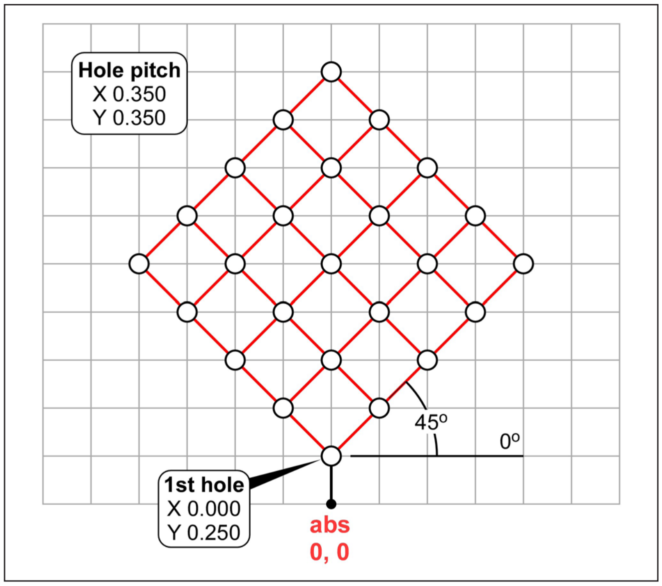


Figure 18 **Example (1) of Grid drilling**

Example (2) Figure 19

Except for the numerical values the procedure is the same as for Example (1). Here the values are:

ENTCNT 0 First hole X coordinate, ***0***
ENTCNT 1 First hole X coordinate, ***0.250***
PITCH X (X axis hole spacing), ***0.500***
PITCH Y (Y axis hole spacing), ***0.300***
ANGLE, ***15***
HOLES X, ***5***
HOLES Y, ***4***

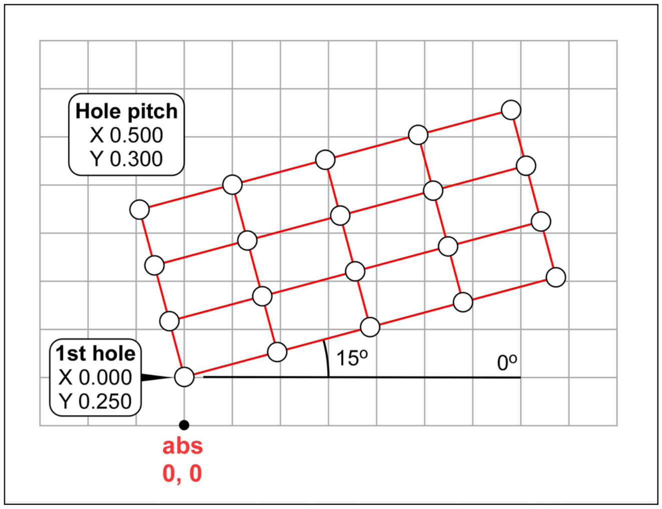


Figure 19 **Example (2) of Grid drilling**

POWER INTERRUPTION

Mill work usually starts with establishing an **abs** workpiece datum, X=0, Y=0, Z=0. In everyday milling operations, with no power interruptions likely, there is no need to make an **abs** datum recoverable — you start the job by setting **abs** to zero at a specific location on the workpiece, and thereafter to work in **inc** or **abs**, whichever is the more convenient.

In cases where the machining process takes more than a single work session, you may have to return to the job after powering down overnight, or after a power interruption during the regular workday.

Provided the machine is not touched when power is off, the **abs** datum is ***saved by the DRO***, and is unaffected. However, if any machine axis is accidentally moved during power-down, the **abs** datum is lost — simply nudging a leadscrew handwheel can result in a small, non-obvious error. Because it eliminates the need to re-establish the starting point, the **Datum Recall** function in the MagXact DRO can be a great time saver.

DATUM RECALL

Each MagXact scale has two separate magnetic tracks, "main" and "reference":
1. The ***main track*** is the source of position data displayed on the DRO.
2. The ***reference track*** is a series of magnetic markers every 50 mm (about 2 inches).

Setting up the DRO for datum recall is simply a matter of relating any one of these reference magnetic markers to a specific physical location on the mill. This is a ***one-time operation***: it sets up approximate “visual reference locations” for the X, Y and Z axes that can be physically marked on the machine (e.g., with a fiber-tip pen). In future work sessions these approximations are used, for each axis, to capture the ***precise location*** of the nearby magnetic marker.

SETTING MACHINE REFERENCES

Starting with the X axis, move the table left or right to a ***provisional*** visual reference location of your choice, literally anywhere in the table’s range of motion. Next, find the magnetic reference track marker nearest to your provisional location as follows:

Datum key

1. Press the **Datum** key on the DRO. The X window displays **homE**.
2. Press the **ent** key. The X window displays **SELECt**.
3. Press the **X** key. The display switches to (or remains in) the ABS mode, and the X window displays a flashing **0**.
4. Slowly move the table until the X display wakes up, begins counting normally. Reverse the table to display **0.0000**.

You are now at the **exact reference point** for the X axis. Mark the machine accordingly (maybe at some point on the table’s front scale). You don't have to be precise about this: for future recall purposes you will need only to reposition the table ***near*** the mark (all your mark has to do is identify a specific magnetic marker, unambiguously, avoiding confusion with neighboring markers 2 inches on either side).

Repeat the above procedure for the Y and Z axes. For these axes the reading heads are usually in view, so their positions can easily be marked on the scales themselves. Again, there is no need to do this precisely.

RELATING A WORKPIECE abs ZERO TO A MACHINE REFERENCE

Some users do this routinely at the beginning of every mill job, others only for a complex, multi-session project. In general, it is always a worthwhile routine practice if there is any risk of a mid-stream power outage. The procedure is done ***separately for each axis***. The following describes X only.

*The following assumes you have completed the above **datum** procedure, and have "found" the exact reference point for the X axis, the display now reading **0.0000**.*

1. Still in **ABS** mode, starting at **X 0.0000**, move the table left or right to bring the mill spindle exactly over the workpiece datum, X = 0. ***Do not zero the display***. (If using a regular-style edge finder, use mental arithmetic to allow for the tip radius, then adjust the table by that amount to set the mill spindle to the datum.)
2. Press the **Datum** key on the DRO. The X window displays **homE**.
3. Press the **6** button twice. The X window displays **SEt MC**.
4. Press the **ent** key. The X window displays **SELECt**.
5. Press the **X** key. The X window displays **0.0000**.

The ABS X = 0 point has now been recorded relative to the machine reference point you set up earlier.

Repeat the process for the Y and Z axes.

Recalling ABS zeros

Do this only if the machine has been moved during a power outage.

The procedure is done ***separately for each axis***. The following describes X only.

1. Select (or remain in) **abs** mode.
2. Move the table close to the X axis reference mark.
3. Press the **Datum** key on the DRO. The X window displays **homE**.
4. Press the **6** button once only. The X window displays **MCrEF**.
5. Press the **ent** key. The X window displays **SELECt**.
6. Press the **X** key. The X window displays a flashing **0**.
7. Slowly move the table until the X display wakes up, just beginning to count normally. Leave the table close to where it was at wake-up.

The original ABS X = 0 point has now been recalled.

Repeat the process for the Y and Z axes.

PRECISE REPOSITIONING OF THE TABLE

The "distance-to-go" key sets up the DRO to count down from the table's current XY position to a specified new location. Similarly, it can be used for Z axis repositioning of the headstock or knee.

Table movement vs. display direction is important here, see Figure 1.

--→0 **Distance-to-go key**

The distance-to-go function has no effect on the ***abs*** zero setting (**XoYo**), which can be anywhere relative to the workpiece.

Referring to Figure 20, suppose the mill spindle is at point **A** and you wish to move the table exactly 3.6 inches to the left, and 2.4 inches forward, to position the spindle over point **B**. In coordinate geometry terms B is "more positive" than A in both axes. (This is consistent with the sign convention shown in Figure 1, where table motion to the left is positive-going for X, and forward motion is positive for Y.)

1. Switch to (or stay in) the ***abs*** mode.
2. Press the **distance-to-go** key. This displays **SELECT** in all three windows.
3. Press the **X** key to select the X axis.
4. Using the keypad enter the X value, ***3.6***, to go from A to B, then press the **ent** key to confirm**.**
5. Press the **Y** key to select the Y axis
6. Using the keypad enter the Y value, ***2.4***, to go from A to B, then press the **ent** key to confirm.
7. Here we are not concerned with the Z axis, so the data entry is complete — no Z axis input. Press the distance-to-go key again to switch the display into the "distance-to-go" mode, decimal point to the left, Figure 12, (X ***. 3.6000***, Y ***. 2.4000***).
8. Move the table left and forward to zero the X and Y axes, then press the **C** key to exit.

If the table is to be moved only in the X axis, skip the Y and Z inputs by pressing the distance-to-go key after Step 4, above.

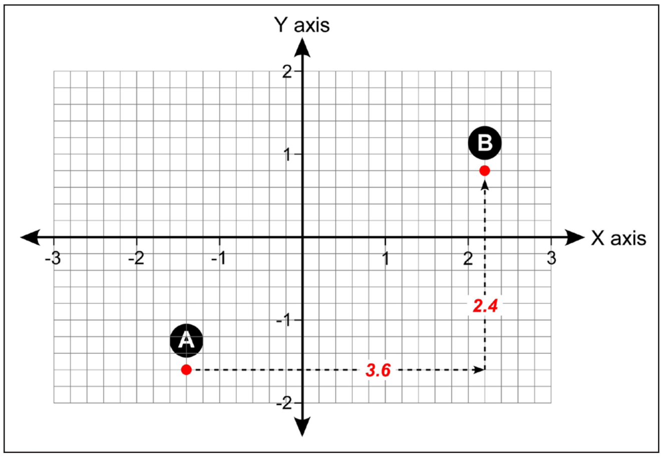


Figure 20 **Repositioning the table by exact amounts**

Reverse direction

If the spindle is at point **B**, and you wish to re-position it to point **A**, the procedure is similar, except that the values for X and Y will be negative. Enter ***3.6 -*** for X, ***2.4- -*** for Y.

SPECIAL FUNCTIONS

ZERO APPROACH WARNING

This function is controlled from the setup menu, page 2. When ***Zero Approach*** is on, a continuous beeping from the DRO warns that the table is approaching the zero value for X or Y.

Zero Approach may be used when recalling an SDM, and also when running macro functions such as PCD, Angle Hole, Distance-to-go.

The beeping stops when the table "nears" zero, but resumes if the table "goes through" zero. The setup menu allows the user to define a ***silent*** (dead) zone on either side of zero. The default values of this zone are:

Approach distance (**BP DIST**) 0.002 inches

Departure tolerance (**BP TOLR**) 0.0000 inches.*

The BP DIST value of 0.002 inches is usable in most situations, but many users increase BP TOLR to at least 0.001 inches. Approach and tolerance values are axis-specific, so X and Y need to be set up independently.

! ***Turning off the keypad BEEP, page 2, does not affect the Zero Approach function. The two beep functions are not linked.***

The setup procedure is as follows:

- Press the **wrench** key at bottom left of the DRO.
- Press either the **X** key or the **Y** key.
- Press the **2** key repeatedly to display **ZERO AP**.
- Press the **ent** key to confirm, displaying **BU22 ON** (= "buzz", beeper ON). If OFF, press the **6** key to turn it ON.
- Press the **2** key to display **BP DIST**. Press the **ent** key to display the selected value (default **000.0020**). If that is the desired value, press the **C** key followed by the **2** key to move on to the next item, **BP TOLR**.

*If instead you wish to change BP DIST, press **ent** again to clear the display (a single **0** remains), then key in the desired value. Press the **ent** key to confirm the value, displaying the next item, BP TOLR.*

- Press the **ent** key to display the selected value of BP TOLR (default **000.0000**). If that is the desired value, press the **C** key followed by the **2** key to move on to the next item, **BEEP**. This refers to the keypad BEEP. If desired, press the **6** key to turn it ON.

*If instead you wish to change BP TOLR, press **ent** again to clear the display (a single **0** remains), then key in the desired value. A value of at least 0.001 is recommended. Press the ent key to confirm, displaying the next item, **BEEP**.* This refers to the keypad BEEP. If desired, press the **6** key to turn it ON.

- Press the **2** key three times to display **SAV CHG** (save changes). Press the **ent** key to confirm, then exit the setup menu by double-clicking the **C** key.
- Repeat the above procedure for the other axis, X or Y.

RESTORE THE DRO TO "AS-SHIPPED" CONDITION

- Press the **wrench** key at bottom left of the DRO. This will display **SELECT** in the uppermost (X axis) window.
- Select any axis, **X**, **Y** or Z.
- Press the **2** key (down arrow) repeatedly to scroll down to **OEM MOD** (this is the last menu item before **END**).
- Press the **ent** key to confirm, displaying **Enter/Loc/Code**.
- Key-in the password **3 5 7 2 6** (no numbers will be displayed).
- Press the **ent** key to confirm, displaying **3 AXIS**.
- Press the **2** key three times, displaying **MILL**, followed by **OPT OFF**, then **SAV CHG**.
- Press the **ent** key to confirm, displaying **RST DEF**.
- Press the **ent** key to confirm, displaying **IN PROG**.

Let the DRO sit for about two minutes to complete the resetting process, after which time the display will resume its normal functions (0.000 for all three axes, in metric mode).

* This may vary depending on the firmware installed.